MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Which of the following has your "address" in the correct order?
   A) you, Earth, solar system, Milky Way, Local Group, Local Supercluster
   B) you, Earth, solar system, Local Group, Local Supercluster, Milky Way
   C) you, Earth, solar system, Local Group, Milky Way, Local Supercluster
   D) you, Earth, Local Group, Local Supercluster, solar system, Milky Way
   E) you, Earth, solar system, Milky Way, Local Supercluster, Local Group

2) Which of the following statements about the celestial sphere is not true?
   A) The celestial sphere does not exist physically.
   B) The "celestial sphere" is just another name for our universe.
   C) From any location on Earth, we can see only half the celestial sphere at any one time.
   D) When we look in the sky, the stars all appear to be located on the celestial sphere.
   E) Earth is placed at the center of the celestial sphere.

3) Which of the following statements about the celestial equator is true at all latitudes?
   A) It extends from your horizon due north, through your zenith, to your horizon due south.
   B) It represents an extension of Earth's equator onto the celestial sphere.
   C) It extends from your horizon due east, through your zenith, to your horizon due west.
   D) It lies along the band of light we call the Milky Way.
   E) It cuts the dome of your sky exactly in half.

4) How many stars can you see with your naked eye on a clear, moonless night from a dark location?
   A) about a hundred thousand
   B) a few thousand
   C) less than a thousand
   D) about ten thousand
   E) more than you could count in your lifetime

5) What is the **ecliptic**?
   A) the Sun's apparent path along the celestial sphere
   B) the constellations commonly used in astrology to predict the future
   C) the Sun's daily path across the sky
   D) the Moon's apparent path along the celestial sphere
   E) when the Moon passes in front of the Sun

6) Which scientists played a major role in overturning the ancient idea of an Earth-centered universe, and about when?
   A) Copernicus, Kepler, and Galileo; about 400 years ago
   B) Aristotle and Copernicus; about 400 years ago
   C) Huygens and Newton; about 300 years ago
   D) Aristotle and Plato; about 2,000 years ago
   E) Newton and Einstein; about 100 years ago
7) Which of the following correctly describes the *meridian* in your sky?
   A) a half-circle extending from your horizon due east, through your zenith, to your horizon due west
   B) the point directly over your head
   C) the boundary between the portion of the celestial sphere you can see at any moment and the portion that you cannot see
   D) a half-circle extending from your horizon due north, through your zenith, to your horizon due south
   E) a half-circle extending from your horizon due east, through the north celestial pole, to your horizon due west

8) How many arcseconds are in 1°?
   A) 3,600
   B) 100
   C) 60
   D) 360
   E) 10,000

9) Which of the following statements does not use the term *angular size* or *angular distance* correctly?
   A) You can use your outstretched hand to estimate angular sizes and angular distances.
   B) The angular distance between those two bright stars in the sky is about 2 meters.
   C) The angular size of the Sun is about the same as that of the Moon.
   D) The angular size of the Moon is about 1/2 degree.
   E) The angular distance between those two houses in the distance is 30°.

10) What is a *circumpolar* star?
    A) a star that is close to the south celestial pole
    B) a star that is close to the north celestial pole
    C) a star that makes a daily circle around the celestial sphere
    D) a star that always remains above your horizon
    E) a star that is visible from the Arctic or Antarctic circles

11) We describe a position on Earth’s surface by stating its
    A) altitude and azimuth.
    B) latitude and longitude.
    C) altitude and direction.
    D) latitude and direction.
    E) meridian and longitude.

12) What makes the North Star, Polaris, special?
    A) It is the brightest star in the sky.
    B) It appears very near the north celestial pole.
    C) It is the star directly on your northern horizon.
    D) It is the star straight overhead.
    E) It can be used to determine your longitude on Earth.

13) Orion is visible on winter evenings but not summer evenings because of
    A) the location of Earth in its orbit.
B) interference from the full Moon.
C) baseball on television.
D) the tilt of Earth’s axis.
E) the precession of Earth’s axis.

14) Which of the following is not a phase of the Moon?
   A) third-quarter Moon
   B) new Moon
   C) half Moon
   D) first-quarter Moon
   E) full Moon

15) If the Moon is setting at 6 A.M., the phase of the Moon must be
   A) first quarter.
   B) new.
   C) third quarter.
   D) full.
   E) waning crescent.

16) Which of the following never goes in retrograde motion?
   A) Mars
   B) Saturn
   C) Jupiter
   D) the Sun
   E) Venus

17) Roughly how many stars are in the Milky Way Galaxy?
   A) 1 billion
   B) 100 trillion
   C) 100 million
   D) 10 billion
   E) 100 billion

18) What is an astronomical unit?
   A) any basic unit used in astronomy
   B) the length of time it takes Earth to revolve around the Sun
   C) the average speed of Earth around the Sun
   D) the diameter of Earth’s orbit around the Sun
   E) the average distance from Earth to the Sun

19) How did Eratosthenes estimate the size of Earth in 240 B.C.?
   A) by sending fleets of ships around Earth
   B) by comparing the maximum altitude of the Sun in two cities at different latitudes
   C) by measuring the size of Earth’s shadow on the Moon in a lunar eclipse
   D) by observing the duration of a solar eclipse
   E) We don’t know how he did it since all his writings were destroyed.

20) Why did Ptolemy have the planets orbiting Earth on “circles upon circles” in his model of the universe?
   A) to properly account for the varying distances of the planets from Earth
   B) to explain why more distant planets take longer to make a circuit through the
constellations of the zodiac
C) to explain why Venus goes through phases as seen from Earth
D) to explain why the Greeks were unable to detect stellar parallax
E) to explain the fact that planets sometimes appear to move westward, rather than eastward, relative to the stars in our sky

21) Where was the Sun in Ptolemy’s model of the universe?
   A) at the center
   B) between the orbits of Venus and Mars
   C) slightly offset from the center
   D) at the outer edge, beyond Saturn's orbit
   E) between Earth and the Moon’s orbit

22) The controversial book of this famous person, published in 1543 (the year of his death), suggested that Earth and other planets orbit the Sun.
   A) Ptolemy
   B) Kepler
   C) Copernicus
   D) Galileo
   E) Tycho Brahe

23) He discovered that the orbits of planets are ellipses.
   A) Tycho Brahe
   B) Ptolemy
   C) Kepler
   D) Copernicus
   E) Galileo

24) He discovered that Jupiter has moons.
   A) Ptolemy
   B) Tycho Brahe
   C) Kepler
   D) Aristotle
   E) Galileo

25) From Kepler’s third law, an asteroid with an orbital period of 8 years lies at an average distance from the Sun equal to
   A) 2 astronomical units.
   B) 4 astronomical units.
   C) 8 astronomical units.
   D) 16 astronomical units.
   E) It depends on the asteroid’s mass.

26) What is meant by a *hypothesis*?
   A) a tentative understanding of a natural phenomenon
   B) a pseudoscientific idea
   C) an explanation for a phenomenon that makes a prediction
   D) a natural phenomenon that requires explanation
   E) a historical theory that has been proved inaccurate

27) Which of the following was *not* observed by Galileo?
   A) stellar parallax
B) craters on the Moon
C) sunspots
D) phases of Venus
E) Jupiter’s moons

28) If your mass is 60 kg on Earth, what would your mass be on the Moon?
   A) 60 lb
   B) 10 kg
   C) 60 kg
   D) 50 kg
   E) 10 lb

29) What would happen if the Space Shuttle were launched with a speed greater than Earth’s escape velocity?
   A) It would take less time to reach its bound orbit.
   B) It would travel away from Earth into the solar system.
   C) It would orbit Earth at a faster velocity.
   D) It would be in an unstable orbit.
   E) It would travel in a higher orbit around Earth.

30) The movement of a pool ball, after being struck by a cue, is an example of
   A) conservation of momentum.
   B) Newton’s second law of motion.
   C) Newton’s third law of motion.
   D) Newton’s first law of motion.
   E) the universal law of gravitation.

31) The force of gravity is an inverse square law. This means that, if you double the distance between two large masses, the gravitational force between them
   A) weakens by a factor of 2.
   B) weakens by a factor of 4.
   C) also doubles.
   D) is unaffected.
   E) strengthens by a factor of 4.

32) According to the universal law of gravitation, if you double the masses of both attracting objects, then the gravitational force between them will
   A) not change at all.
   B) decrease by a factor of 4.
   C) increase by a factor of 4.
   D) increase by a factor of 2.
   E) decrease by a factor of 2.

33) The mass of Jupiter can be calculated by
   A) measuring the orbital period and distance of Jupiter’s orbit around the Sun.
   B) measuring the orbital period and distance of one of Jupiter’s moons.
   C) knowing the Sun’s mass and measuring how Jupiter’s speed changes during its elliptical orbit around the Sun.
   D) measuring the orbital speed of one of Jupiter’s moons.
   E) knowing the Sun’s mass and measuring the average distance of Jupiter from the Sun.
34) At which lunar phase(s) are tides most pronounced (e.g., the highest high tides)?
   A) new Moon
   B) full Moon
   C) first quarter
   D) both new and full Moons
   E) both first and third quarters

35) An atom in an excited state contains more of what type of energy than the same atom in the ground state?
   A) mass-energy
   B) electric potential energy
   C) gravitational potential energy
   D) kinetic energy
   E) thermal energy

36) If a material is highly opaque, then it
   A) scatters most light.
   B) reflects most light.
   C) transmits most light.
   D) emits most light.
   E) absorbs most light.

37) The wavelength of a wave is
   A) equal to the speed of the wave times the wave's frequency.
   B) the distance between two adjacent peaks of the wave.
   C) the distance between where the wave is emitted and where it is absorbed.
   D) how strong the wave is.
   E) the distance between a peak of the wave and the next trough.

38) How are wavelength, frequency, and energy related for photons of light?
   A) Longer wavelength means lower frequency and higher energy.
   B) Longer wavelength means higher frequency and lower energy.
   C) Longer wavelength means higher frequency and higher energy.
   D) Longer wavelength means lower frequency and lower energy.
   E) There is no simple relationship because different photons travel at different speeds.

39) From lowest energy to highest energy, which of the following correctly orders the different categories of electromagnetic radiation?
   A) radio, X rays, visible light, ultraviolet, infrared, gamma rays
   B) visible light, infrared, X rays, ultraviolet, gamma rays, radio
   C) gamma rays, X rays, visible light, ultraviolet, infrared, radio
   D) infrared, visible light, ultraviolet, X rays, gamma rays, radio
   E) radio, infrared, visible light, ultraviolet, X rays, gamma rays

40) When an atom loses an electron, it becomes
   A) dissociated.
   B) an isotope.
   C) a plasma.
   D) ionized.
   E) sublimated.
41) When an electron in an atom goes from a higher energy state to a lower energy state, the atom
   A) can emit a photon of any frequency.
   B) can absorb a photon of any frequency.
   C) emits a photon of a specific frequency.
   D) absorbs a photon of a specific frequency.
   E) absorbs several photons of a specific frequency.

42) If two objects are the same size but one object is 3 times hotter than the other object, the hotter object emits
   A) 12 times more energy.
   B) 3 times more energy.
   C) 9 times more energy.
   D) 81 times more energy.
   E) none of the above

43) The spectra of most galaxies show redshifts. This means that their spectral lines
   A) have wavelengths that are longer than normal.
   B) have wavelengths that are shorter than normal.
   C) always are in the red part of the visible spectrum.
   D) have a higher intensity in the red part of the spectrum.
   E) have normal wavelengths, but absorption of light makes them appear red.

44) From laboratory measurements, we know that a particular spectral line formed by hydrogen appears at a wavelength of 121.6 nanometers (nm). The spectrum of a particular star shows the same hydrogen line appearing at a wavelength of 121.8 nm. What can we conclude?
   A) The star is getting hotter.
   B) The “star” actually is a planet.
   C) The star is getting colder.
   D) The star is moving away from us.
   E) The star is moving toward us.

45) Suppose you see two stars: a blue star and a red star. Which of the following can you conclude about the two stars? Assume that no Doppler shifts are involved. (Hint: Think about the laws of thermal radiation.)
   A) The blue star has a hotter surface temperature than the red star.
   B) The blue star is farther away than the red star.
   C) The red star has a hotter surface temperature than the blue star.
   D) The blue star is more massive than the red star.
   E) The red star is more massive than the blue star.

46) Telescopes operating at this wavelength must be cooled to observe faint astronomical objects.
   A) visible
   B) X-ray
   C) radio
   D) extreme infrared
   E) gamma-ray

47) Suppose the angular separation of two stars is smaller than the angular resolution of your eyes. How will the stars appear to your eyes?
A) You will not be able to see these two stars at all.
B) You will see only the larger of the two stars, not the smaller one.
C) You will see two distinct stars.
D) The two stars will look like a single point of light.
E) The two stars will appear to be touching, looking rather like a small dumbbell.

48) Which of the following statements best describes the two principal advantages of telescopes over eyes?
A) Telescopes have much more magnification and better angular resolution.
B) Telescopes can collect far more light with far better angular resolution.
C) Telescopes can collect far more light with far greater magnification.
D) Telescopes collect more light and are unaffected by twinkling.
E) Telescopes can see farther without image distortion and can record more accurate colors.

49) What do astronomers mean by light pollution?
A) Light pollution refers to harmful gases emitted by common street lights.
B) Light pollution is another name for sunlight, which makes it impossible to see stars in the daytime.
C) Light pollution refers to pollution caused by light industry as opposed to heavy industry.
D) Light pollution refers to light used for human activities that brightens the sky and hinders astronomical observations.
E) Light pollution refers to the lights that must be used inside major observatories and that make it difficult for astronomers’ eyes to adapt to darkness.

50) Which of the following is not an advantage of the Hubble Space Telescope over ground-based telescopes?
A) It can observe infrared and ultraviolet light, as well as visible light.
B) Stars do not twinkle when observed from space.
C) Observers on the ground can use it at any time of day (i.e., not only during their night).
D) It is closer to the stars.
E) It never has to close because of bad weather.

51) In what part of the electromagnetic spectrum do the biggest telescopes on Earth operate?
A) visible
B) infrared
C) X-ray
D) radio
E) ultraviolet

52) How do asteroids differ from comets?
A) Asteroids are made of icy material and are less dense than the comets, which are rockier.
B) Asteroids and comets are both made of rocky and icy material, but asteroids are smaller in size than comets.
C) Asteroids are rocky bodies and are denser than the comets, which are made of icy material.
D) Asteroids are made of icy material and are denser than the comets, which are more rocky.
E) Asteroids are rocky bodies and are less dense than the comets, which are made of icy material.

53) How does the Sun’s mass compare with that of the planets?
   A) It is a thousand times more massive than Earth.
   B) It is a thousand times more massive than all the planets combined.
   C) It is a hundred times more massive than all the planets combined.
   D) It is a hundred times more massive than Earth.
   E) It is about as massive as all the planets combined.

54) Which planet has the highest average surface temperature, and why?
   A) Venus, because of its dense carbon dioxide atmosphere
   B) Mars, because of its red color
   C) Mercury, because of its dense carbon dioxide atmosphere
   D) Jupiter, because it is so big
   E) Mercury, because it is closest to the Sun

55) Which planet, other than Earth, has visible water ice on it?
   A) Mercury
   B) Jupiter
   C) Mars
   D) Venus
   E) the Moon

56) Which of the following is furthest from the Sun?
   A) a comet in the Kuiper belt
   B) Pluto
   C) Neptune
   D) a comet in the Oort cloud
   E) an asteroid in the asteroid belt

57) Which of the following is not an exception to the general patterns of motion in the solar system?
   A) the extreme axis tilt of Uranus
   B) the counterclockwise rotation of Venus
   C) the large size of Earth’s Moon
   D) the rings of Saturn
   E) the retrograde rotation of Triton around Neptune

58) Which is the densest planet in the solar system?
   A) Mercury
   B) Mars
   C) Jupiter
   D) Venus
   E) Earth

59) The planet closest in size to Earth is
   A) Pluto.
   B) Venus.
   C) the Moon.
   D) Mercury.
   E) Mars.
60) Which of the following is not a characteristic of the inner planets?
   A) They are relatively smaller than the outer planets.
   B) They have very few, if any, satellites.
   C) They all have solid, rocky surfaces.
   D) They all have substantial atmospheres.
   E) Their orbits are relatively closely spaced.

61) Which of the following is not a characteristic of the outer planets?
   A) They have very few, if any, satellites.
   B) They are primarily made of hydrogen and helium.
   C) They are all large balls of gas.
   D) Their orbits are separated by relatively large distances.
   E) They all have rings.

62) What is aerobraking?
   A) the technique of using a planetary atmosphere to change the orbit of a spacecraft
   B) the destruction of a spacecraft by the intense pressure as it descends into the atmosphere
   C) the gradual decrease of speed as a spacecraft leaves the solar system
   D) the use of a planetary atmosphere to redirect a spacecraft to another planet
   E) the controlled landing of a spacecraft on a planetary surface

63) Which of the following is not an advantage of spacecraft flybys over ground-based telescope observations?
   A) Spacecraft can sample the gravitational field of a planet.
   B) Spacecraft can make highly detailed images of the planet and its moons.
   C) Spacecraft can monitor changes in a planet's atmosphere over long times.
   D) Spacecraft can measure local magnetic fields.
   E) Spacecraft can view "backlit" views of planetary rings.

64) Why did the solar nebula heat up as it collapsed?
   A) As the cloud shrank, its gravitational potential energy was converted to kinetic energy and then into thermal energy.
   B) Nuclear fusion occurring in the core of the protosun produced energy that heated the nebula.
   C) Collisions among planetesimals generated friction and heat.
   D) The shock wave from a nearby supernova heated the gas.
   E) Radiation from other nearby stars that had formed earlier heated the nebula.

65) What percentage of the solar nebula's mass consisted of rocky material?
   A) 0.4 percent
   B) 20 percent
   C) 0 percent
   D) 2 percent
   E) 80 percent

66) What kind of material in the solar nebula could remain solid at temperatures as high as 1,500 K, such as existed in the inner regions of the nebula?
   A) molecules such as methane and ammonia
   B) rocks
What was the frost line of the solar system?
A) the distance from the Sun where temperatures were low enough for metals to condense, between the Sun and the present-day orbit of Mercury
B) the distance from the Sun where temperatures were low enough for hydrogen compounds to condense into ices, between the present-day orbits of Mars and Jupiter
C) the distance from the Sun where temperatures were low enough for rocks to condense, between the present-day orbits of Mercury and Venus
D) the distance from the Sun where temperatures were low enough for hydrogen and helium to condense, between the present-day orbits of Jupiter and Saturn
E) the distance from the Sun where temperatures were low enough for asteroids to form, between the present-day orbits of Venus and Earth

According to the nebular theory, what are asteroids and comets?
A) They are chunks of rock or ice that were expelled from planets by volcanoes.
B) They are the shattered remains of collisions between planets.
C) They are the shattered remains of collisions between moons.
D) They are leftover planetesimals that never accreted into planets.
E) They are chunks of rock or ice that condensed long after the planets and moons had formed.

The heavy bombardment phase of the solar system lasted
A) to the present time.
B) several tens of millions of years.
C) several million years.
D) about a billion years.
E) several hundreds of millions of years.

The nebular theory of the formation of the solar system successfully predicts all but one of the following. Which one does the theory not predict?
A) Planets orbit around the Sun in nearly circular orbits in a flattened disk.
B) the compositional differences between the terrestrial and jovian planets
C) the equal number of terrestrial and jovian planets
D) asteroids, Kuiper-belt comets, and the Oort cloud
E) the craters on the Moon

Rank the five terrestrial worlds in order of size from smallest to largest:
A) Mercury, Moon, Venus, Earth, Mars.
B) Moon, Mercury, Mars, Venus, Earth.
C) Mercury, Venus, Earth, Moon, Mars.
D) Mercury, Moon, Mars, Earth, Venus.
E) Moon, Mercury, Venus, Earth, Mars.

Which of the following most likely explains why Venus does not have a strong magnetic field?
A) Its rotation is too slow.
B) It has too thick an atmosphere.
C) It is too close to the Sun.
D) It does not have a metallic core.
E) It is too large.

73) Which two properties are most important in determining the surface temperature of a planet?
   A) composition and distance from the Sun
   B) size and atmosphere
   C) internal temperature and atmosphere
   D) size and chemical composition
   E) distance from the Sun and atmosphere

74) Which of the following does not have a major effect in shaping planetary surfaces?
   A) tectonics
   B) volcanism
   C) magnetism
   D) erosion
   E) impact cratering

75) The relatively few craters that we see within the lunar maria
   A) were formed by impacts that occurred after those that formed most of the craters in the lunar highlands.
   B) are sinkholes that formed when sections of the maria collapsed.
   C) were formed by impacts that occurred before those that formed most of the craters in the lunar highlands.
   D) are volcanic in origin, rather than from impacts.
   E) were created by the same large impactor that led to the formation of the maria.

76) The Caloris Basin on Mercury covers a large region of the planet, but few smaller craters have formed on top of it. From this we conclude that
   A) the Caloris Basin formed toward the end of the solar system's period of heavy bombardment.
   B) the Caloris Basin was formed by a volcano.
   C) Mercury's atmosphere prevented smaller objects from hitting the surface.
   D) only very large impactors hit Mercury's surface in the past.
   E) erosion destroyed the smaller craters that formed on the basin.

77) Olympus Mons is a
   A) stratovolcano on Mercury.
   B) large lava plain on the Moon.
   C) shield volcano on Mars.
   D) shield volcano on Venus.
   E) stratovolcano on the Moon.

78) Why does Venus have such a great difference in temperature between its "no atmosphere" temperature and its actual temperature?
   A) It has a large amount of greenhouse gases in its atmosphere.
   B) It has a high level of volcanic activity.
   C) It has no cooling effects from oceans.
   D) It is so close to the Sun.
   E) It has a slow rotation.

79) What are greenhouse gases?
A) gases that absorb visible light  
B) gases that absorb ultraviolet light  
C) gases that transmit infrared light  
D) gases that transmit visible light  
E) gases that absorb infrared light

80) There are no aurora on Venus because it  
A) is too hot.  
B) lacks atmospheric oxygen.  
C) lacks a strong magnetic field.  
D) lacks an ionosphere.  
E) lacks strong winds.

81) Where is most of the water on Mars?  
A) in its polar caps and subsurface ground ice  
B) in deep underground deposits  
C) frozen on the peaks of its tall volcanoes  
D) in its clouds  
E) distributed evenly throughout its atmosphere

82) Why is Mars red?  
A) Its surface rocks were rusted by oxygen.  
B) Its surface is made of ices that absorb blue light.  
C) Its atmosphere scatters blue light more effectively than red light.  
D) Its surface is made of ices that absorb red light.  
E) It is made primarily of red clay.

83) How does Jupiter’s core compare to Earth’s?  
A) It is about the same size but is 10 times more massive.  
B) Jupiter doesn’t have a core—it is made entirely from hydrogen and helium.  
C) It is about 10 times larger both in size and mass.  
D) It is the same size and mass.  
E) It is about 10 times larger in size and the same mass.

84) The fact that most moons always show the same face to their planet is  
A) a result of the fact that the moons once had atmospheres.  
B) explained by the law of conservation of angular momentum.  
C) a natural consequence of the fact that the entire solar nebula rotated in the same direction.  
D) a natural consequence of tidal forces acting on the moons.  
E) very surprising and a great mystery.

85) What is the most important reason why an icy moon is more likely to be geologically active than a rocky moon of the same size?  
A) Ice has a lower melting point than rock.  
B) Ice is less dense than rock.  
C) Ice contains more radioactive elements than rock.  
D) Ice is less rigid than rock.  
E) Ice is affected by tidal forces to a greater extent than rock.

86) Why is Jupiter denser than Saturn?  
A) It has a greater proportion of helium to hydrogen compared to Saturn.
B) The extra mass of Jupiter compresses its interior to a greater extent than that of Saturn.
C) Its core is much larger than Saturn’s.
D) It is made of a different composition than Saturn, including a higher proportion of hydrogen compounds and rocks.
E) It is unknown why this is so.

87) What is Jupiter’s Great Red Spot?
   A) a long-lived, high-pressure storm
   B) a large mountain peak poking up above the clouds
   C) the place where reddish particles from Io impact Jupiter’s surface
   D) a hurricane that comes and goes on Jupiter
   E) the place where Jupiter’s aurora is most visible

88) The four Galilean moons around Jupiter are
   A) all made of rock.
   B) a mixture of rock and ice, with the ice fraction increasing with distance from Jupiter.
   C) a mixture of rock and ice, with the rock fraction increasing with distance from Jupiter.
   D) hydrogen and helium gas.
   E) all made of ice.

89) Why are there no impact craters on the surface of Io?
   A) Io did have impact craters but they have all been buried in lava flows.
   B) It is too small to have been bombarded by planetesimals in the early solar system.
   C) Any craters that existed have been eroded through the strong winds on Io’s surface.
   D) Io’s thick atmosphere obscures the view of the craters.
   E) Jupiter’s strong gravity attracted the planetesimals more strongly than Io and thus none landed on its surface.

90) Which moon has the most substantial atmosphere?
   A) Mimas
   B) Titan
   C) Io
   D) Europa
   E) Ganymede

91) How thick are Saturn’s rings from top to bottom?
   A) a few kilometers
   B) a few tens of meters
   C) a few hundred kilometers
   D) a few tens of thousands of kilometers
   E) a few million kilometers

92) Which is closest to the average distance between asteroids in the asteroid belt?
   A) 1 million km
   B) 1 thousand km
   C) 10 thousand km
   D) 100 thousand km
E) 10 million km

93) Why isn’t there a planet where the asteroid belt is located?
A) The temperature in this portion of the solar nebula was just right to prevent rock from sticking together.
B) There was not enough material in this part of the solar nebula to form a planet.
C) Gravitational tugs from Jupiter prevented material from collecting together to form a planet.
D) There was too much rocky material to form a terrestrial planet, but not enough gaseous material to form a jovian planet.
E) A planet once formed here, but it was broken apart by a catastrophic collision.

94) What do we call a small piece of solar system debris found on Earth?
A) solar system debris
B) cometary fragment
C) meteor
D) meteorite
E) meteoroid

95) Halley’s comet is named after the English scientist Edmund Halley because he
A) calculated its orbit and predicted that it would return in 1758.
B) was the first to see it in 1682.
C) discovered it.
D) was the most famous astronomer in England during its appearance.
E) was the first to publish pictures of it and report it to the International Astronomical Union (IAU).

96) What part of a comet points most directly away from the Sun?
A) the coma
B) the dust tail
C) the plasma tail
D) the nucleus
E) the jets of gas

97) Most of the planets discovered around other stars
A) are more massive than Earth and orbit very far from the star.
B) are more massive than Earth and orbit very close to the star.
C) are less massive than Earth and orbit very far from the star.
D) are found around neutron stars.
E) are less massive than Earth and orbit very close to the star.

98) What is astrometry?
A) measuring distances to stars
B) searching for planets around stars
C) measuring the positions of stars on the sky
D) using metric units for distance (e.g. meters rather than light years)
E) measuring the velocities of stars via the Doppler effect

99) Current techniques can measure stellar motion to less than
A) cruising speed of an airplane.
B) freeway speed.
C) orbital speed of Jupiter.
D) running speed.
E) walking speed.

100) Why are many of the newly detected extrasolar planets called "hot Jupiters"?
   A) because the discovery of other planets is very exciting
   B) Their masses and composition are similar to what we would expect if Jupiter
      were hotter.
   C) Their masses are similar to Jupiter but their composition is similar to Mercury.
   D) Their masses are similar to Jupiter but they are very close to the central star
      and therefore hot.
   E) The planets tend to be detected around more massive, hotter stars than our
      Sun.

101) The core of the Sun is
   A) at the same temperature and density as the surface.
   B) constantly rising to the surface through convection.
   C) at the same temperature but denser than the surface.
   D) hotter and denser than the surface.
   E) composed of iron.

102) What two forces are balanced in what we call gravitational equilibrium?
   A) outward pressure and gravity
   B) the strong force and kinetic energy
   C) outward pressure and the strong force
   D) the strong force and gravity
   E) the electromagnetic force and gravity

103) What is the average temperature of the surface of the Sun?
   A) 10,000 K
   B) 1 million K
   C) 1,000 K
   D) 6,000 K
   E) 100,000 K

104) Which layer of the Sun do we normally see?
   A) corona
   B) photosphere
   C) convection zone
   D) chromosphere
   E) radiation zone

105) At the center of the Sun, fusion converts hydrogen into
   A) radiation and elements like carbon and nitrogen.
   B) helium, energy, and neutrinos.
   C) plasma.
   D) hydrogen compounds.
   E) radioactive elements like uranium and plutonium.